A Research Reactor Concept To Support NTP Development

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Nuclear and Emerging Technology for Space

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Introduction

Ultimate NASA Goal

- Development of a Man-Rated NTR Engine

Path Forward

- Build On Past Development Work/Effort
  - "Don't Reinvent the Wheel"
- Continue Work With Excellent Existing Resources and Partners
  - Especially DOE
- Build Organic/Internal NASA Capability to Support Research
  - Complimentary to Existing Resources
  - Not Replacing

Introduction (cont)

Specific Target Area for This Discussion

Potential NASA Research Reactor

Specifics

Technical Details Covered Later

Provides Capabilities that are Additive to the Current Research Mix

Also by Teaming with Multiple Partners (Particularly Academic)

Supports Enhanced Research and Educational Opportunities

In Line with Atomic Energy Act

Regulatory Aspects

The Concept Currently Under Discussion

LEU Research Reactor

NASA Site

NASA is Licensee

Significant Benefits

Primary Regulatory Jurisdiction of NRC

Completely Public Licensing Process

Challenges Due to Uniqueness of Design

This is a New Application for a Research Reactor

It’s Been a While

Status

Various Details are Being Discussed

Additional Specifics Required to Proceed "Officially"

NASA Has Initiated Discussions

"Drop-In" Basis

Next Steps

Pre-Application Discussions

Public Meetings

NRC Review Scheduling

Application Submission

If the Decision is Made to Proceed

Status (cont)

More Next Steps

- Scheduling Support for Review
  - Advance Planning Year(s) Prior
- Review
  - Public Meetings
    - Closed Portions Allowed
  - Duration
    - Safely Say More than 1 FY

Summary

Potential Research Reactor

Additive Capability to Research Mix

NASA Site

NRC Licensing

Anticipate Engagement of All Current NASA Partners in NTR Effort

- In Particular Continued Extensive DOE Engagement and Support
- Simply a Continuation of the Successful Working Relationship between NASA and DOE
- Significant University Involvement/Support
- Industry Support

Bottom Line

This is just one possible path to support the development effort for NTRs.

And the research reactor being considered could be one of the tipping points in achieving complete success.

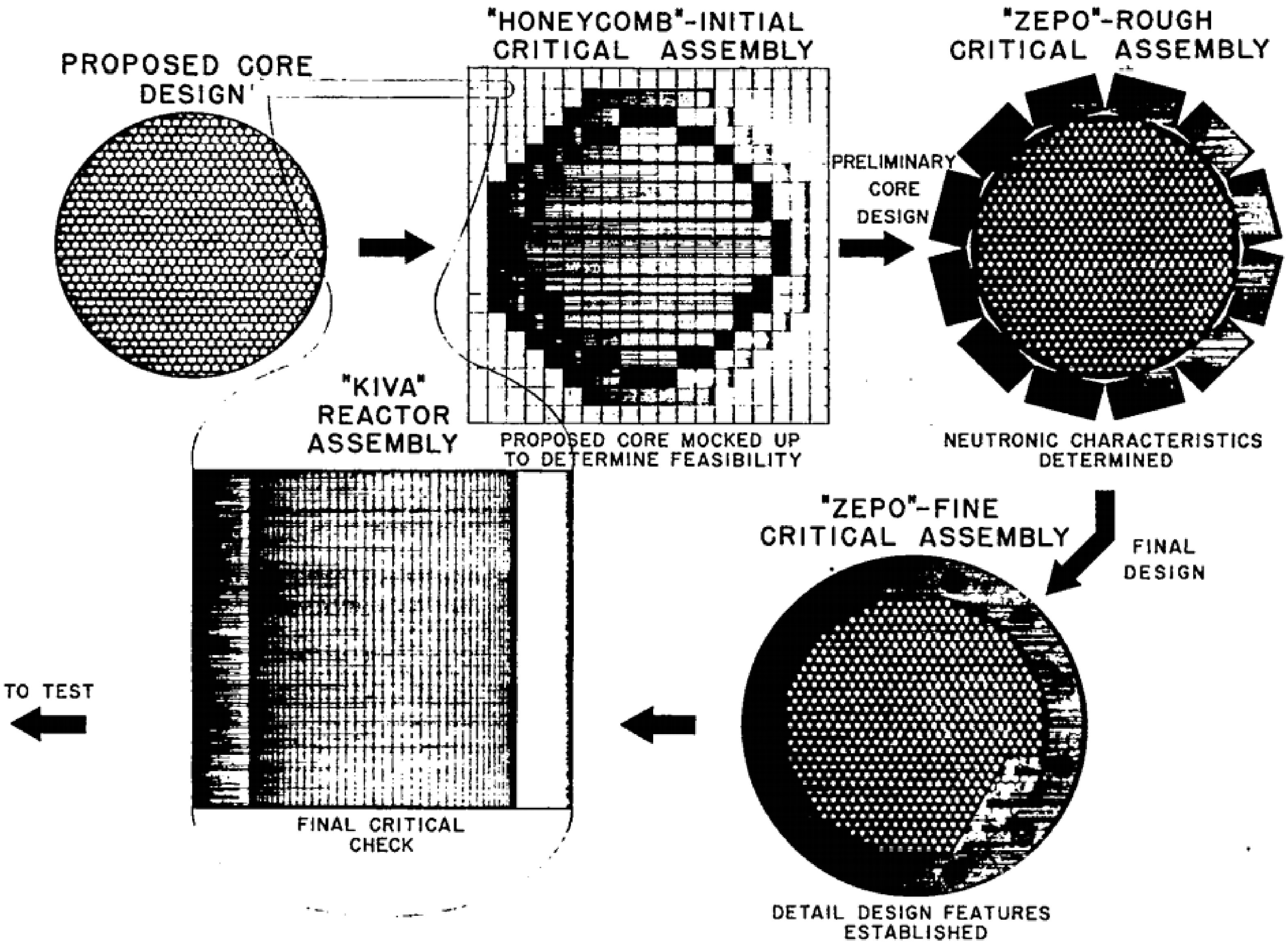
But the success of the NTR effort will require all segments (government, academic and corporate) to continue working together for the common good and a common goal.

We have to remember that NTR technology is (just) one of the potential game changers for the exploration and commercialization of space.

There can be no vested interests here – we are all on the same side. There are no star players – we must function as a team. That is how we succeed.

Technical Discussion

In the NERVA Program



From "A Review of Fuel Element Development for Nuclear Rocket Engines" J. M. Taub

Back then…

Nuclear research was cheaper

Computer models were less rigorous

Regulation was less stringent

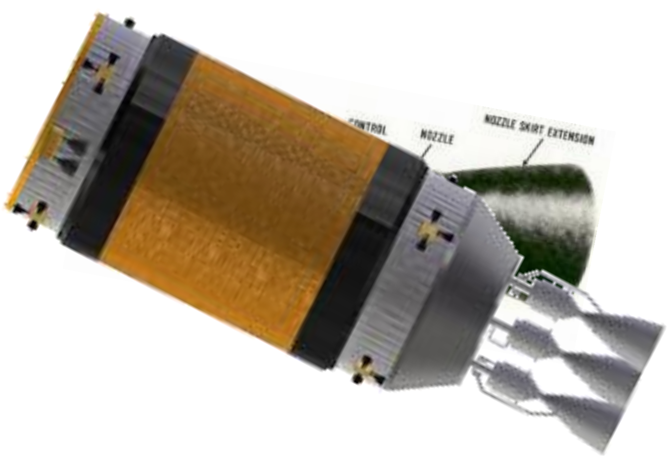
Overview

Proposed:

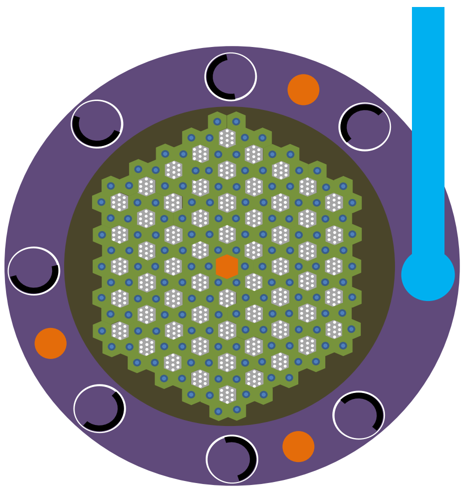
A NRC regulated reactor to act as a milestone to a full ground test.

Complementary to the nation’s existing facilities

Nuclear Thermal Propulsion Research Reactor (NTPRR)



NTP Concept

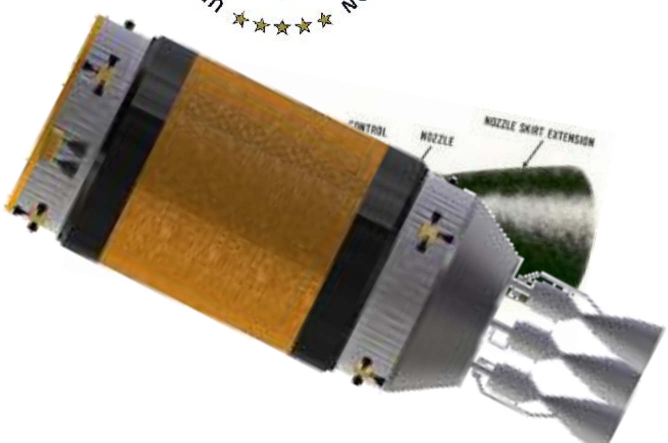


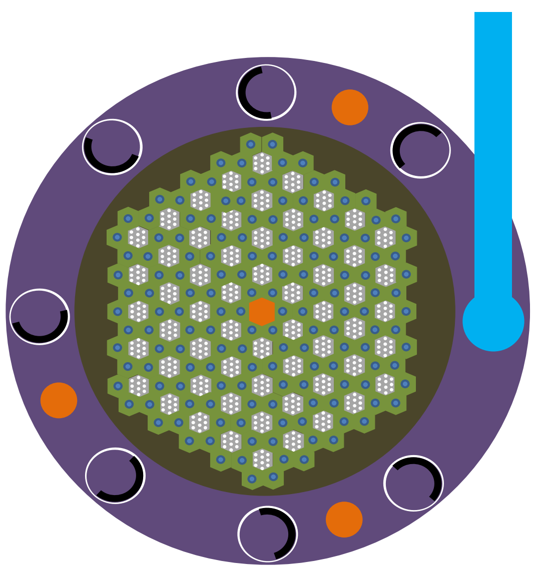
NTPRR

Overview

2 Stakeholders

NTP Development and Spinoff Applications





Stakeholders

NTR Development Support

Builds expertise at test site and working with regulators

Benchmark for codes

Provides a characteristic NTR environment for materials and fuel testing.

Relatively low cost fission heat milestone

Utilize existing regulatory structures

Potential Research Reactor Concept

10 MW

Tungsten-UO_2 Cermet LEU fuel

Gas cooled

$ZrH_{1.8}$ moderated

Beryllium reflected

Turbine and Compressor

High Temperature Operation

Different fuels and fuel configurations

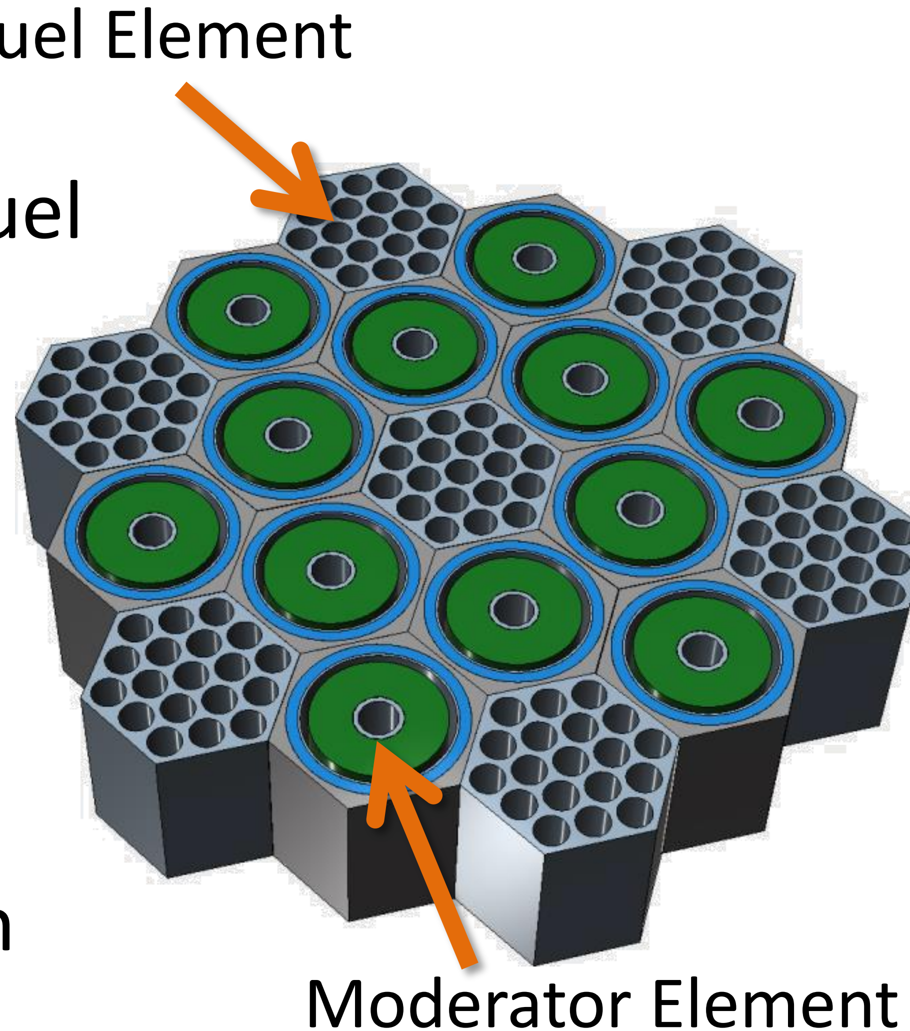


Image and concept from Design of a Low-Enriched Nuclear Thermal Rocket CSNR Gwyn Rosaire, Peter Husemeyer, Paolo Venneri, Wesley Deason

Spinoff Applications

Academic Partners

Why:

Spread out cost and maximize benefit of investment in a research reactor

A NTR research reactor will be a unique tool for the nation

High temperature operation and hard flux

Radiation damage studies

Fast Neutron Activation Analysis

Benchmark Gas Cooled Reactor Codes

Unique Isotope Production

Calibration of fast neutron detectors

More Than NTP!

High Temperature

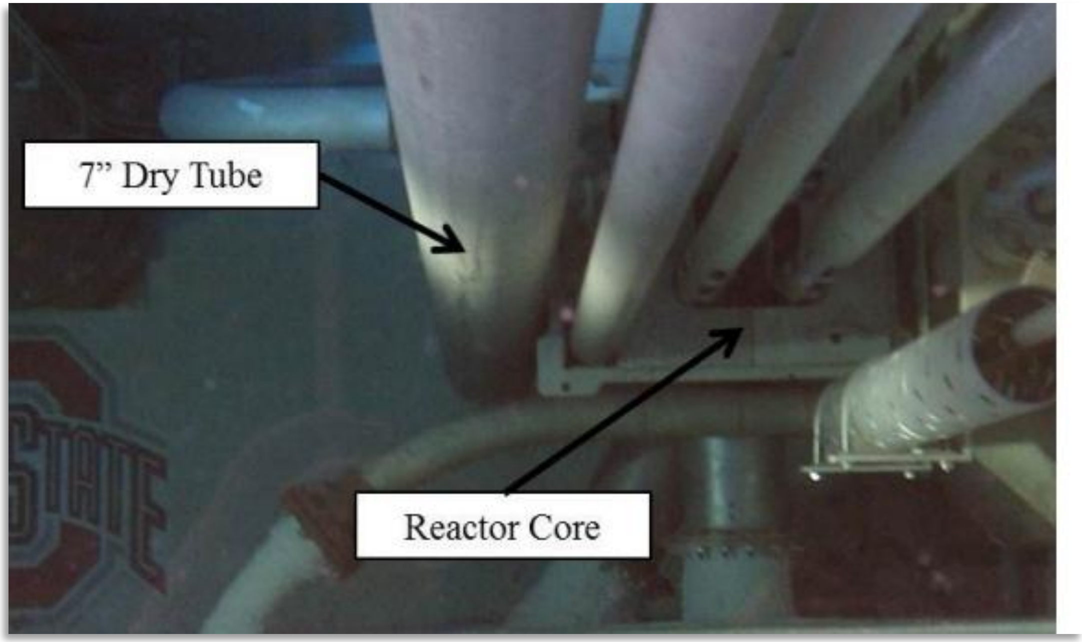
A disposable furnace used at the Ohio State Research Reactor

Bulk Exit Temperature

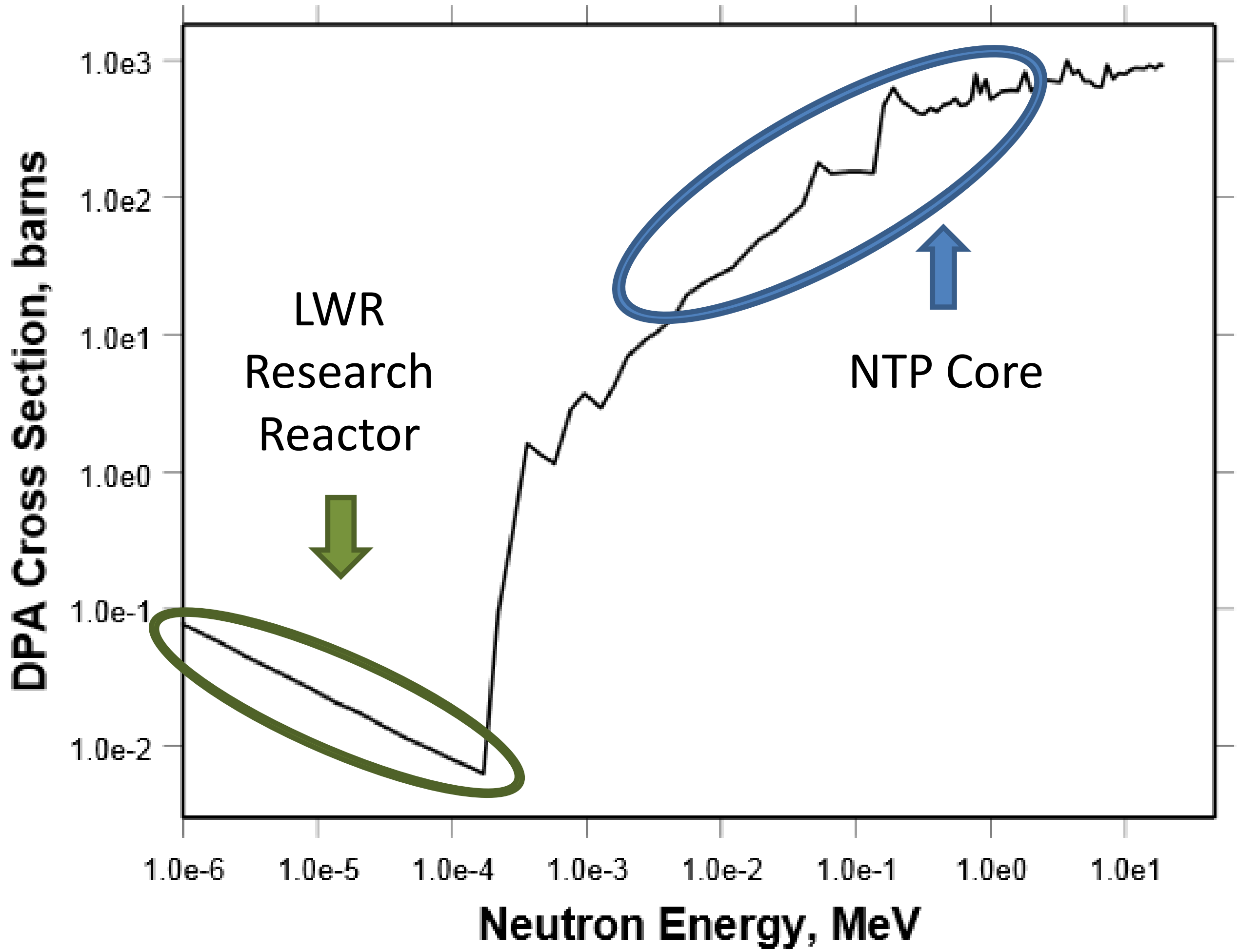
Advanced Test Reactor: 71 °C

High Flux Isotope Reactor: 69°C

NTP core: ~2500 °C



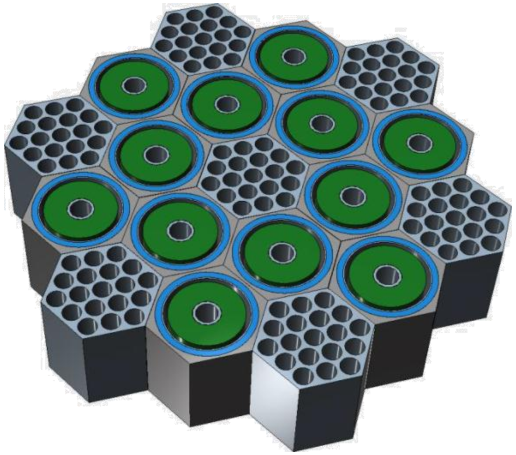
Harder Spectrum, SiC example

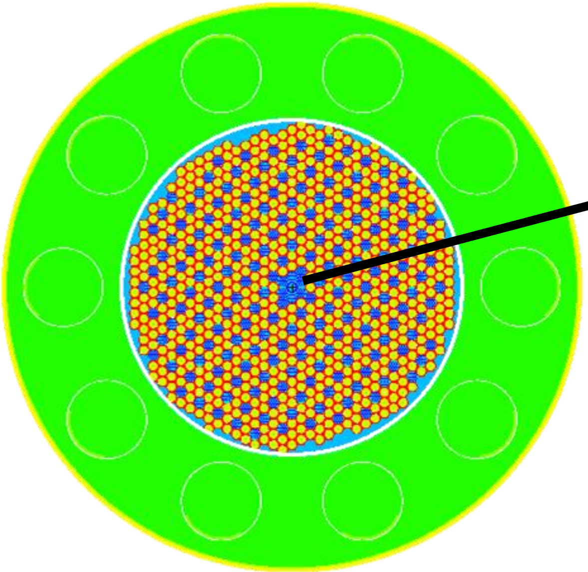


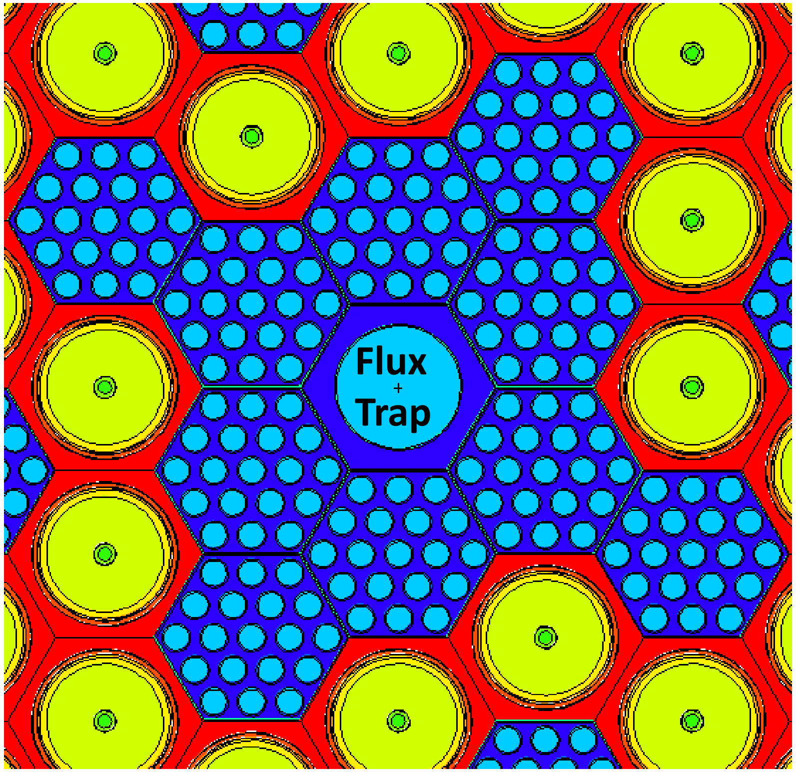
Similar trends can be found all through out radiation damage

Image edited from TOTAL DPA CROSS SECTIONS FOR SIC AS A FUNCTION OF NEUTRON ENERGY H. L. Heinisch, et. Al.

Initial MCNP Results

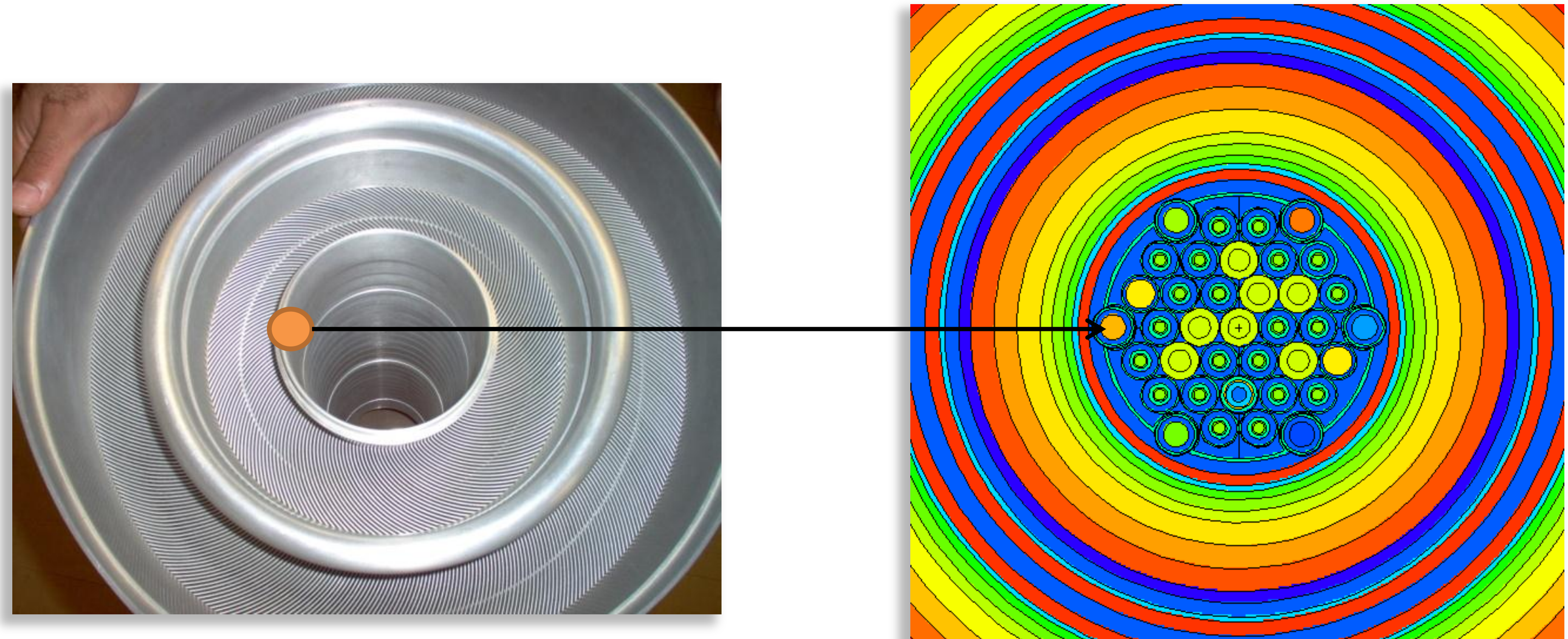






Unoptimized NTP core Flux Trap

Initial MCNP Results

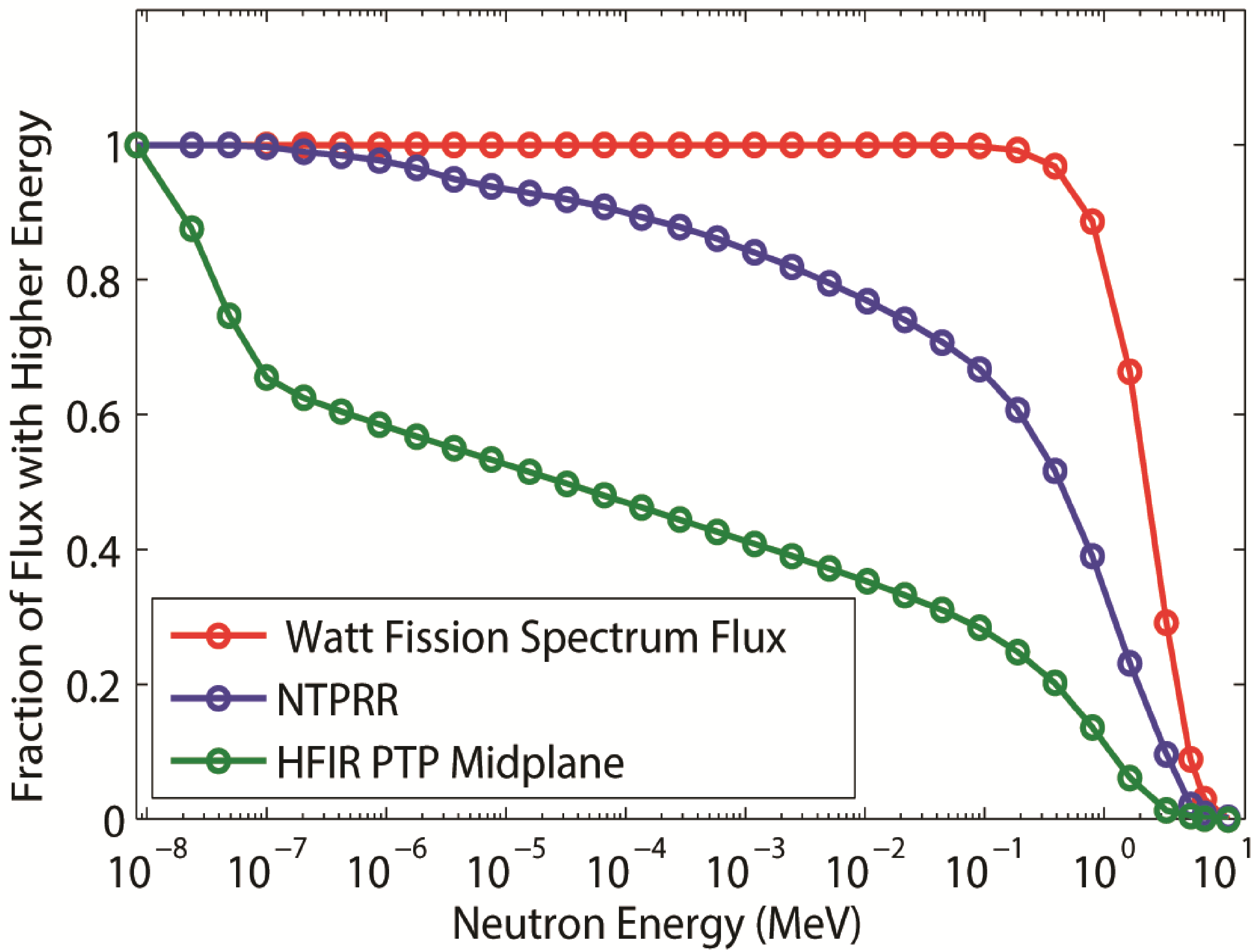


HFIR Peripheral Target Position

-Often used for DPA Studies

Images from HFIR and HFIRs MCNP input deck at http://neutrons.ornl.gov

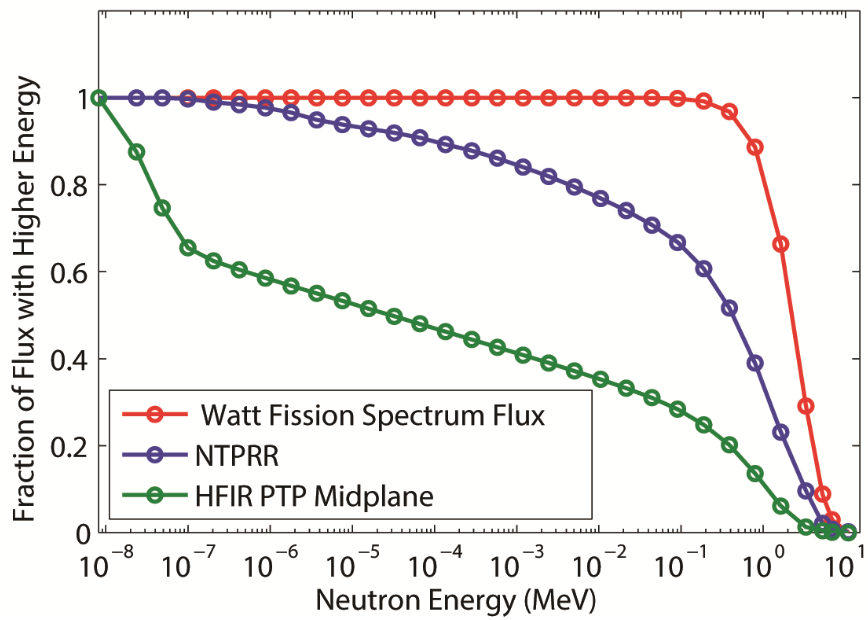
Unoptimized Initial Results



Unoptimized Initial Results

NTPRR 3.3×10^{14} at 10 MW,
~4.2 dpa in SiC per EFPY

HFIR PTP 3.8×10^{15} at 85 MW,
~28 dpa in SiC per EFPY



First stage irradiations before running an experiment in HFIR or ATR.

Radiation damage studies requiring specialty fluxes and high temperatures.

Isotope Production

Fast neutron sources offer unique isotope production capabilities

(n,p) reaction for ^{32}P, ^{33}P, ^{35}S, ^{57}Co, ^{64}Cu, ^{67}Cu, and ^{89}Sr

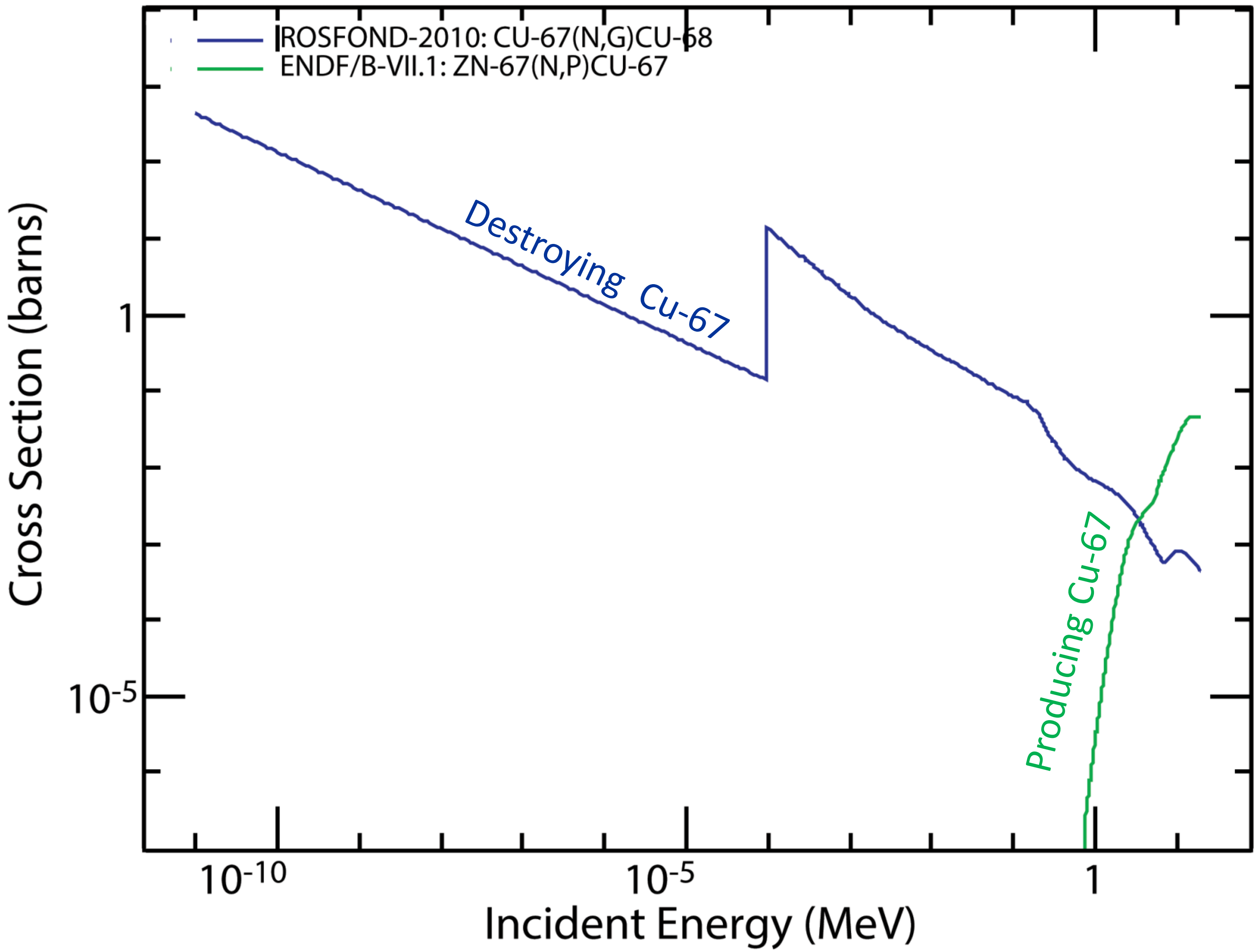
Favorable spectrum for (n,γ) for ^{127}Xe, ^{131}I and ^{198}Au

Fast spectrum Isotope production demonstrated in BR-10

Producing ^{64}Cu and ^{67}Cu for medical purposes identified as a research priority Nuclear Science Advisory Committee Isotopes Subcommittee

Often only 1 or 2 suppliers exist for some isotopes

Cu-67 production from Zn-67

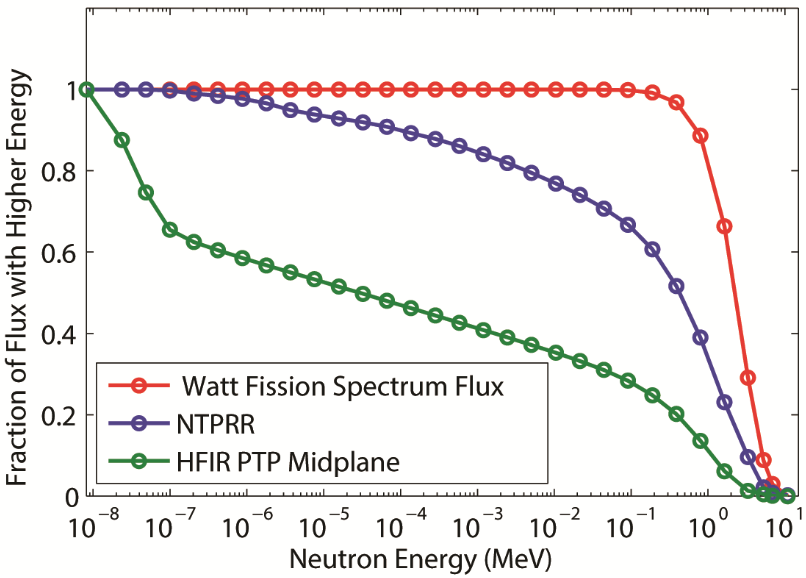


Summary

- A NTPRR could play an important role in affordable NTP development.

- A NTPRR would have many spinoff applications and complement the nation’s current research reactor capabilities.

Questions



Fraction of Flux with Higher Energy
0
0.2
0.4
0.6
0.8
1
10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1}
Neutron Energy (MeV)
Watt Fission Spectrum Flux
NTPRR
HFIR PTP Midplane